Link Aggregation Interoperability

of the Dell PowerConnect 5316M Switch and Cisco Switches

This article explains how to configure the Dell™ PowerConnect™ 5316M Gigabit Ethernet switch, which resides within the Dell Modular Server Enclosure, to interoperate and connect with Cisco IOS-based and CatOS-based switches by using industry-standard link aggregation groups that adhere to the IEEE 802.3ad standard.

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The Cisco IOS and CatOS operating systems run on Cisco network switches and provide Cisco EtherChannel, Fast EtherChannel (FEC), and Gigabit EtherChannel (GEC) technologies, which enable network administrators to group ports on Cisco switches together to increase available throughput. Dell PowerConnect switches offer a similar technology known as link aggregation groups (LAGs), which are designed to increase the overall bandwidth between two Dell switches by aggregating multiple ports to act as a single, logical connection between the switches. Dell PowerConnect 5316M switches implement IEEE 802.3ad–based link aggregation, which is interoperable with Cisco EtherChannel technology.[1]

Link aggregation on Dell PowerConnect switches can be configured as either dynamic or static. The dynamic configuration uses the IEEE 802.3ad standard, which is also known as Link Aggregation Control Protocol (LACP). LACP enables a Gigabit Ethernet switch to confirm that the external switch is also configured for link aggregation. Static configuration is used when connecting the Dell PowerConnect 5316M Gigabit Ethernet switch to an external Gigabit Ethernet switch that does not support LACP. In a static configuration, a cabling or configuration mistake involving the PowerConnect 5316M or the external switch could go undetected and thus could cause undesirable network behavior. Both static and dynamic LAGs (via LACP) can detect physical link failures within the LAG and continue forwarding traffic through the other connected links within that same LAG. LACP can also detect switch or port failures that do not result in the loss of a link, helping provide a more resilient LAG. Best practices suggest using dynamic link aggregation instead of static link aggregation.

The examples presented in this article use the command-line interface (CLI) of the Dell PowerConnect 5316M to configure the switch.[2] These example configurations also can be implemented via the Web-based graphical user interface (GUI) of the PowerConnect 5316M.[3]

[1] In dynamic configurations, this interoperability is possible only via LACP, not the proprietary Cisco Port Aggregation Protocol (PAgP). Link aggregation interoperability for all Dell PowerConnect products is tested at the University of New Hampshire InterOperability Lab. This lab tests products for the Bridge Functions Consortium, which includes leading vendors of switch and networking products. For more information, visit ftp://ftp.iol.unh.edu/pub/bfc/testsuites/la.io.test.suite.pdf.

[2] For more information about configuring LAGs via the CLI., see the "Port Channel Commands" section of the *Dell PowerConnect 5316M CLI Reference Guide* at support.dell.com/support/edocs/network/PC5316M/en/CLI/portchan.htm#1016308.

[3] For more information about configuring LAGs via the GUI, see the "Defining LAG Parameters" section of the *Dell PowerConnect 5316M Ethernet Switch Module User's Guide* at support.dell.com/support/edocs/network/PC5316M/en/UG/switch.htm#1125197.

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Link aggregation with Gigabit Ethernet switches

The following examples show minimal configurations necessary to establish a LAG between a Cisco IOS-based Gigabit Ethernet switch (Catalyst 3750), Cisco CatOS-based Ethernet switch (Catalyst 6509), and the Dell PowerConnect 5316M Gigabit Ethernet switch. These commands should work properly when using the default configuration of each switch. *Note:* These commands will erase any configuration data previously configured and reboot the switch.

To set the Dell PowerConnect 5316M to the default configuration, administrators should issue the following commands:

```
5316M# delete startup-config
5316M# reload
```

To set the Cisco IOS-based Catalyst 3750 switch to the default configuration, administrators should issue the following commands:

```
3750# delete flash:/config.text
3750# reload
```

To set the Cisco CatOS-based Catalyst 6509 switch to the default configuration, administrators should issue the following commands:

```
Cat_6509 (enable) clear config all
```

Please see the "Configuration limitations" section in this article for scenarios in which resetting the switches to factory defaults would be impractical.

The Dell PowerConnect 5316M can support up to eight LAGs. A port channel can have from zero to six of the external ports as members. Internal ports cannot be members of a LAG. The examples in this article use different numbers of ports in a LAG.

Best practices recommend that the ports to be aggregated on both the Cisco and Dell switches be disconnected during configuration. This will avoid any network loops being formed before the LAG is set up.

Configuring the PowerConnect 5316M external ports for dynamic link aggregation

The following example shows the Dell PowerConnect 5316M CLI commands for configuring the six external ports on the Gigabit Ethernet switch for LACP:

```
5316M(config)# interface range ethernet g11-16
5316M(config-if)# channel-group 1 mode auto
```

The first command sets the CLI mode to configure the six external Gigabit Ethernet ports (referred to in the command as `g11-16`, which represents Gigabit Ethernet ports 11 through 16). All 6 ports do not have to be selected; a LAG can have from zero to six ports, depending on the requirements of the network. The number of ports in the LAG correlates to the amount of bandwidth and redundancy achievable in the network—that is, the more ports, the more bandwidth and redundancy. A LAG can even be configured without any member ports. When ports are added to the LAG, they will be set to the configuration of the LAG.

The second command aggregates the six ports into a LAG (referred to in the command as `channel-group`), which will use LACP (referred to in the command as `mode auto`). The channel-group number, which is 1 in this example, has meaning only within the switch and is used to differentiate up to eight unique channel-groups. For each LAG created, administrators must designate it with a number between one and eight for up to eight groups. Only the external ports (11 through 16) can be part of a LAG.

Configuring a Cisco IOS-based Gigabit Ethernet switch for dynamic link aggregation

The following example shows the Cisco IOS-based switch CLI commands for configuring six ports for LACP:

```
3750(config)# interface range GigabitEthernet
   1/0/1 - 6
3750(config-if)# channel-protocol lacp
3750(config-if)# channel-group 1 mode active
```

The first command sets the CLI mode to configure six Gigabit Ethernet ports (referred to in the command as `GigabitEthernet 1/0/1 - 6`, which represents Gigabit Ethernet ports 1 through 6). The second command sets ports to use LACP as the LAG protocol (and not PAgP). The third command aggregates the six ports into a LAG (referred to in the command as `channel-group`), which will use LACP (referred to in the command as `mode active`). The channel-group number, which is 1 in this example, has meaning only within the switch and is used to differentiate unique channel-groups.

Configuring a Cisco CatOS-based Gigabit Ethernet switch for dynamic link aggregation

The following example shows the Cisco CatOS-based switch CLI commands for configuring six ports for LACP:

```
Cat_6509(enable) set channelprotocol lacp 2
Cat_6509(enable) set port lacp-channel 2/1-6
   mode active
```

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```
5316M# show interfaces port-channel 1
Channel   Ports
.......   .....
ch1       Active: g(11-16)
```

Figure 1. Using the show interfaces command to confirm a LAG connection for the Dell PowerConnect 5316M

The first command sets the LAG dynamic protocol to LACP on module 2 (in this example, this module in the switch is used to validate the examples in this article; other switches may be configured differently). The second command aggregates six ports on module 2 (referred to in the command as `2/1-6`, which represents ports 1 through 6 on module 2) into a LAG (referred to in the command as `lacp-channel`), which will use LACP (referred to in the command as `mode active`).

Note: Only the "active" Cisco mode is supported for LACP interoperability with the Dell PowerConnect 5316M. The other modes ("passive," "auto," "on," and "desirable") should not be used when using LACP between a Cisco switch and the PowerConnect 5316M. This is a common configuration error.

Confirming a successful dynamic link aggregation connection with the PowerConnect 5316M

Figure 1 provides an example usage of the `show interfaces` command, which can be issued to help ensure that the Dell PowerConnect 5316M switch has established a LAG and that the LAG is connected. The output of this command shows that ports 11 through 16 are active. This confirms that there is physical link on all ports in the LAG and that the PowerConnect 5316M has communicated with the Cisco switch to successfully establish an aggregated link on ports 11 through 16 with LACP.

Confirming a successful dynamic link aggregation connection with Cisco IOS

Figure 2 provides an example of the Cisco IOS `show interfaces` command, which can be used to help ensure that the Cisco IOS-based switch has established a LAG and that the LAG is connected. The output of this command shows that ports 1/0/1 through 1/0/6 are active. This confirms that there is physical link on all ports in the LAG and that the Cisco switch has communicated with the PowerConnect 5316M switch to successfully establish an aggregated link on ports 1/0/1 through 1/0/6 with LACP.

Confirming a successful dynamic link aggregation connection with Cisco CatOS

Figure 3 provides an example usage of the Cisco CatOS `show lacp-channel info` command, which can be used to help ensure that the Cisco CatOS-based switch has established a LAG and that the LAG is connected. The output of this command shows that the status of ports 2/1 through 2/6 is "connected" and the channel mode of these ports is "active." This confirms that there is physical link on all ports in the LAG and that the Cisco switch has communicated with the PowerConnect 5316M switch to successfully establish an aggregated link on ports 2/1 through 2/6 with LACP.

Configuring the PowerConnect 5316M external ports for static link aggregation

The following example shows the Dell PowerConnect 5316M CLI commands for configuring three external ports of the Gigabit Ethernet switch for static aggregation:

```
5316M(config)# interface range ethernet g13-15
5316M(config-if)# channel-group 1 mode on
```

Note that a LAG can be configured with zero to six ports (this example uses three ports), but a port can be part of only a single LAG. The first command sets the CLI mode to configure three external Gigabit Ethernet ports (13 through 15). The second command aggregates the three ports into a static LAG. Static LAGs do not use LACP and are defined in the CLI by setting the channel-group mode to "on." The channel-group number, which is 1 in this example,

```
3750# show interfaces port-channel 1 etherchannel
Port-channel1   (Primary aggregator)

Age of the Port-channel  = 00d:01h:11m:34s
Logical slot/port        = 10/1
Number of ports          = 6
HotStandBy port          = null
Port state               = Port-channel Ag-Inuse
Protocol                 = LACP

Ports in the Port-channel:

Index  Load     Port      EC state     No of bits
------+------+---------+------------+------------
  0      00     Gi1/0/1   Active           0
  0      00     Gi1/0/2   Active           0
  0      00     Gi1/0/3   Active           0
  0      00     Gi1/0/4   Active           0
  0      00     Gi1/0/5   Active           0
  0      00     Gi1/0/6   Active           0
```

Figure 2. Using the show interfaces command to confirm a LAG connection for a Cisco IOS-based switch

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```
Cat_6509> (enable) show lacp-channel info
Chan Port  Status      Channel    Admin  Speed   Duplex  Vlan
id                     mode       group
---- ----- ---------- --------- -----  -----   ------  ----
801  2/1   connected   active     395   a-1Gb   a-full   1
801  2/2   connected   active     395   a-1Gb   a-full   1
801  2/3   connected   active     395   a-1Gb   a-full   1
801  2/4   connected   active     395   a-1Gb   a-full   1
801  2/5   connected   active     395   a-1Gb   a-full   1
801  2/6   connected   active     395   a-1Gb   a-full   1
                          . . .
```

Figure 3. Using the show lacp-channel info command to confirm a LAG connection for a Cisco CatOS-based switch

has meaning only within the switch and is used to differentiate up to eight unique channel-groups. For each LAG created, administrators must designate it with a number between one and eight for up to eight groups. The internal ports that connect to the servers do not support LAGs.

Configuring a Cisco IOS-based switch for static link aggregation

The following example shows the Cisco IOS CLI commands for configuring three ports of the Cisco switch for static link aggregation:

```
3750(config)# interface range GigabitEthernet
   1/0/9 - 11
3750(config-if)# channel-group 1 mode on
```

The first command sets the CLI mode to configure three Gigabit Ethernet ports (1/0/9 through 1/0/11). The second command aggregates the three ports into a static LAG. Static LAGs do not use LACP and are defined in the Cisco CLI by setting the channel-group mode to "on." The channel-group number, which is 1 in this example, has meaning only within the switch and is used to differentiate channel-groups. The number of channel-groups supported by Cisco switches depends on the switch model.

Configuring a Cisco CatOS-based switch for static link aggregation

The Cisco CatOS CLI allows the configuration of static LAGs via LACP or PAgP commands. The following example shows the Cisco CatOS CLI LACP `channelprotocol` commands for configuring three ports of the Cisco switch for static link aggregation:

```
Cat_6509(enable) set channelprotocol lacp 2
Cat_6509(enable) set port lacp-channel 2/9-11 mode on
```

The first command sets module 2 to use the LACP commands to configure LAGs. Because a static LAG is being defined, the setting for the `channelprotocol` command does not matter. The second command configures the three Ethernet ports (2/9 through 2/11) into a static LAG. Static LAGs do not use LACP and are defined in the Cisco CLI by setting the lacp-channel mode to "on."

The following example shows the Cisco CatOS CLI PAgP `channelprotocol` commands for configuring three ports of the Cisco switch for static link aggregation using the PAgP command:

```
Cat_6509(enable) set channelprotocol pagp 2
Cat_6509(enable) set port channel 2/9-11
   mode on
```

The first command sets module 2 to use the PaGP commands to configure LAGs. As mentioned before, the setting for the `channelprotocol` command does not matter because a static LAG is being defined. The second command configures the three Ethernet ports (2/9 through 2/11) into a static LAG. Static LAGs do not use PAgP and are defined in the Cisco CLI by setting the channel mode to "on."

Confirming a successful static link aggregation connection

When LACP is not being used, only careful inspection of the Cisco and PowerConnect 5316M configurations can confirm that a static LAG has been established. Administrators can take the following steps to help confirm the connection:

1. Check that the cabling is connected to the correct ports on both switches.
2. Check that all the LAG ports have a link.
3. Use the `show running-config` command to confirm that the desired ports are in the LAG:
   - **PowerConnect 5316M:** `5316M# show running-config`
   - **Catalyst 3750:** `3750# show running-config`
   - **Catalyst 6509:** `Cat_6509(enable) show running-config`

Link aggregation with Cisco Fast Ethernet switches

Some enterprise IT organizations use Cisco Fast Ethernet (100 Mbps) network switches. In this case, they may not want to incur the expenses to replace the Cisco Fast Ethernet switches to match the high speed of the Dell PowerConnect 5316M Gigabit Ethernet switch, but they probably still want to achieve the most bandwidth possible. Because the PowerConnect 5316M switch supports auto-negotiation, administrators do not need to perform any additional steps to connect aggregated links to a Cisco Fast Ethernet switch if the Cisco switch's link aggregation ports are also set to auto-negotiation.

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The ports in a Dell PowerConnect 5316M LAG are set to auto-negotiation by default. If the negotiation setting of the LAG has been changed because of a previous switch configuration, administrators can use the following command to set the LAG ports back to auto-negotiation:

```
5316M(config)# interface port-channel 1
5316M(config-if)# negotiation
```

To set the ports on a Cisco IOS-based switch to auto-negotiation, administrators can use the following commands:

```
2950(config)# interface range FastEthernet 0/1 - 3
2950(config-if)# speed auto
2950(config-if)# duplex auto
```

To set the ports on a Cisco CatOS-based switch to auto-negotiation, administrators can use the following command:

```
Cat_6509> (enable) set port speed  2/9-11  auto
```

If auto-negotiation cannot be used, both the Dell PowerConnect LAG and the Cisco switch ports in the LAG must be set to the same speed and duplex. Intermittent link failures may occur if one switch is in auto-negotiation mode and the other is forced to a certain speed and duplex.

The Dell PowerConnect 5316M LAG can be forced to 100 Mbps with the following commands:

```
5316M(config)# interface port-channel 1
5316M(config-if)# no negotiation
5316M(config-if)# speed 100
```

In this example, the LAG is referred to in the command as `port-channel 1`. The `no negotiation` command means that there is no auto-negotiation on the ports in the LAG. The `speed 100` command specifies all the ports in the LAG to be 100 Mbps. Because this is a LAG configuration, and the 802.3ad standard requires all ports in a LAG to be full duplex, administrator do not need to set the duplex to full (and in fact, cannot do so via the PowerConnect 5316M CLI). The duplex is set to full by default on LAG ports.

Note: This process differs from the Cisco IOS and CatOS methods, which require that all the ports in the LAG be configured to 100 Mbps and full duplex rather than setting the LAG to 100 Mbps. Configuring all ports in a LAG to 100 Mbps and full duplex on the Dell PowerConnect 5316M switch would have no effect because the LAG configuration takes precedence over individual port configurations.

Administrators can use the following commands to set the ports on the Cisco IOS-based switch to 100 Mbps and full duplex:

```
2950(config)# interface range FastEthernet 0/1 - 3
2950(config-if)# speed 100
2950(config-if)# duplex full
```

Administrators can use the following commands to set the ports on the Cisco CatOS-based switch to 100 Mbps and full duplex:

```
Cat_6509> (enable) set port speed 2/9-11 100
Cat_6509> (enable) set port duplex 2/9-11 full
```

Configuration limitations

Ports to be aggregated must be configured so that they are compatible with the link aggregation feature and with the switch to which they will be connected. For the Dell PowerConnect 5316M, the following limitations apply to aggregated ports (the commands to remove the configuration are shown immediately after each limitation):

- The port cannot have an IP address defined on it:
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no ip address
```

- The port cannot belong to another LAG:
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no channel-group
```

- The port cannot be a mirrored port:
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no port monitor gxx
```

- The port cannot have GARP (Generic Attributes Registration Protocol) VLAN (virtual LAN) Registration Protocol (GVRP) enabled:
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no gvrp enable
```

- The port cannot belong to an access VLAN other than the default VLAN (1):
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no switchport access vlan
```

- The port cannot belong to a trunk VLAN other than the default VLAN (1):
```
5316M(config)# interface Ethernet g11
5316M(config-if)# no switchport trunk native vlan
```

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```
5316M(config-if)# exit
5316M(config)# exit
5316M# show running-config
interface range ethernet g(13-16)
channel-group 1 mode on
exit
interface ethernet g11
gvrp enable
exit
```

Figure 4. Example output for the show running-config command showing GVRP enabled

```
5316M# show running-config
interface port-channel 1
speed 100
no negotiation
exit
interface ethernet g11
speed 10
no negotiation
exit
interface range ethernet g(11,13-16)
channel-group 1 mode on
exit
```

Figure 5. Example output for the show running-config command showing differing LAG and port speeds

- The internal switch ports (g1 through g10) cannot be part of a LAG. The CLI will prevent adding internal ports to a LAG.

To check the configuration of the ports on the PowerConnect 5316M, administrators can use the `show running-config` command and view the `interface Ethernet gxx` configurations, where *xx* indicates the port number. Figure 4 shows example output after this command has been issued. In this scenario, the `no gvrp enable` command would have to be issued on port g11 before this port could be added to a LAG.

Cisco and Dell port configuration differences

On the Dell PowerConnect 5316M, configurations for the LAG take precedence over the configuration of the ports. In Figure 5, example output from the `show running-config` command shows that port g11 is actually set to 100 Mbps (and not 10 Mbps) because the LAG is set to 100 Mbps. If g11 is removed from the LAG, the port configuration will be applied (that is, g11 would be set to 10 Mbps).

On Cisco IOS- and CatOS-based switches, ports must be configured identically to be included in a LAG. Cisco IOS-based switches can use the "desirable" and "passive" mode options for the LAG setting. The PowerConnect 5316M does not support this implementation, and thus administrators should not use these modes when configuring a LAG with a Dell PowerConnect switch. Instead, they should use only the "active" mode (for LACP configuration) or the "on" mode (for static configuration).

Switches can control the distribution only of outgoing traffic on LAG ports. The PowerConnect 5316M uses a static distribution method based on source and destination Media Access Control (MAC) addresses to decide which port or LAG a packet will travel through.[4]

Cisco IOS- and CatOS-based switches provide configuration options for changing the distribution of traffic on LAG ports. The Cisco IOS commands shown in Figure 6 can be used if the Cisco IOS-based switch performs poorly in the LAG. These commands allow administrators to configure the switch to distribute packets to ports in a LAG based on the following settings: destination IP address, destination Ethernet address, a combination of source and destination IP addresses, a combination of source and destination Ethernet addresses, source IP address, or source Ethernet address.

The Cisco CatOS commands shown in Figure 7 can be used if the Cisco CatOS-based switch performs poorly in the LAG. These commands allow administrators to configure the switch to distribute packets to ports in a LAG based on the following settings: destination IP address, destination Ethernet address, a combination of source and destination IP addresses, a combination of source and destination Ethernet addresses, source IP address, or source Ethernet address.

```
3750(config)#port-channel load-balance dst-ip
3750(config)#port-channel load-balance dst-mac
3750(config)#port-channel load-balance src-dst-ip
3750(config)#port-channel load-balance src-dst-mac
3750(config)#port-channel load-balance src-ip
3750(config)#port-channel load-balance src-mac
```

Figure 6. Cisco IOS commands for configuring packet distribution in a LAG

[4] For an in-depth discussion of this algorithm and network design considerations, see "Network Link Aggregation Practices with the Dell PowerEdge 1855 Blade Server" by Bruce Holmes in *Dell Power Solutions*, May 2005; www.dell.com/downloads/global/power/ps2q05-20040286-Holmes-OE.pdf.

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```
Cat_6509> (enable) set port channel all distribution ip destination
Cat_6509> (enable) set port channel all distribution mac destination
Cat_6509> (enable) set port channel all distribution ip both
Cat_6509> (enable) set port channel all distribution mac both
Cat_6509> (enable) set port channel all distribution ip source
Cat_6509> (enable) set port channel all distribution mac source
```

Figure 7. Cisco CatOS commands for configuring packet distribution in a LAG

Interoperability between Dell and Cisco switches

The standards-based link aggregation feature of the Dell PowerConnect 5316M Gigabit Ethernet switch is designed to interoperate easily with Cisco IOS- and CatOS-based switches. By understanding the differences in the Dell PowerConnect 5316M and Cisco CLIs and building on the examples presented in this article, system administrators can help integrate the PowerConnect 5316M switch into their Cisco-based networks.

Bruce Holmes is a senior test engineer in the Dell PowerConnect Group. He has worked at Dell for two years and supports PowerConnect switches in all phases of product development and testing. He has a B.S. in Electrical Engineering from The University of Texas at Austin.

FOR MORE INFORMATION

Holmes, Bruce. "Network Link Aggregation Practices with the Dell PowerEdge 1855 Blade Server." *Dell Power Solutions,* May 2005. www.dell.com/downloads/global/power/ps2q05-20040286-Holmes-OE.pdf

Dell PowerConnect 5316M Ethernet Switch Module User's Guide:
support.dell.com/support/edocs/network/PC5316M/en/UG

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